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**GENETIC VARIABILITY, CORRELATION AND PATH
ANALYSIS FOR SEED YIELD AND YIELD
CONTRIBUTING CHARACTERS IN SOYBEAN**
,
(*Glycine max* (L.) Merrill)

By

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B.Sc. (Agri.)

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**MASTER OF SCIENCE
(AGRICULTURE)
IN
AGRICULTURAL BOTANY
(GENETICS AND PLANT BREEDING)**

**DEPARTMENT OF AGRICULTURAL BOTANY
COLLEGE OF AGRICULTURE, LATUR
MARATHWADA KRISHI VIDYAPEETH,
PARBHANI - 431402 [Maharashtra], INDIA.**

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DISSERTATION
Submitted To
The Marathwada Krishi Vidyapeeth, Parbhani in Partial Fulfillment
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IN
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(GENETICS AND PLANT BREEDING)

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MARATHWADA KRISHI VIDYAPEETH, PARBHANI -
431402 [Maharashtra], INDIA.

2012

DEDICATED TO...

My Beloved Parents

And

Research guide

*Whose boundless love and silent sacrifices
are
Unmatched by my small achievements...*

...Rahul

CANDIDATE'S DECLARATION

I hereby declare that the dissertation
or part thereof, has not been
previously submitted by
me for a degree of
any University or
Institution

Place: Latur

Date: 16/05/2012


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CERTIFICATE – I

This is to certify that the dissertation entitled “**GENETIC VARIABILITY, CORRELATION AND PATH ANALYSIS FOR SEED YIELD AND YIELD CONTRIBUTING CHARACTERS IN SOYBEAN (*Glycine max* (L.) Merrill)**” submitted by **Shri. BODKHE RAHUL BABASAHEB** to the Marathwada Krishi Vidyapeeth, Parbhani in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE (Agriculture)** in the subject of **GENETICS AND PLANT BREEDING** is record of original and bonafide research work carried out by him under my guidance and supervision. It is of sufficiently high standard to warrant its presentation for the award of the said degree.

I also certify that the dissertation or part thereof has not been previously submitted by him for a degree of any university.

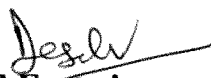
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(**S. P. POLE**)
Research Guide

CERTIFICATE – II

This is to certify that the dissertation entitled “**GENETIC VARIABILITY, CORRELATION AND PATH ANALYSIS FOR SEED YIELD AND YIELD CONTRIBUTING CHARACTERS IN SOYBEAN (*Glycine max* (L.) Merrill)**” Submitted by **Shri. BODKHE RAHUL BABASAHEB** to the **Marathwada Krishi Vidyapeeth, Parbhani** in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE (Agriculture)** in the subject of **GENETICS AND PLANT BREEDING** has been approved by the student’s advisory committee after viva-voce examination in collaboration with the external examiner.


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(Bodkhe R. B.)

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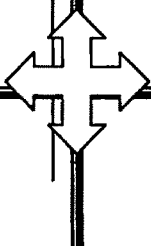
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ABBERRVIATION

%	=	per cent
/	=	per
Σ	=	summation
σ^2	=	variance
C	=	check
cm	=	centimeter(s)
d.f.	=	degree of freedom
EMS	=	error mean sum of square
<i>et al.</i>	=	and other
Fig.	=	Figure
g	=	gram(s)
GCV	=	Genotypic coefficient of variation
PCV	=	Phenotypic coefficient of variation
ha	=	hectare(s)
i.e.	=	that is
MSS	=	mean sum of square
pp	=	pages
r	=	correlation coefficient
viz.,	=	videlicet (namely)
GM	=	general mean

INTRODUCTION



Chapter I

INTRODUCTION

Soybean (*Glycine max* (L). Merrill) occupies a unique position among edible legumes. Traditional food legumes (pulses) are rich in protein but contain limited amount of oil. Soybean contains more protein (about 40-42 per cent) than other pulses and a much higher content of edible oil (about 20 per cent) (Gopalan *et al.*, 1994). It is also rich in lysine (5%), an essential amino acid that is deficient in most of the cereal based diets. Therefore the quality of soy protein is now recognized as being similar to that of meat protein. The edible oil in soybean is approximately 85 per cent unsaturated and contains the essential fatty acids. This crop is also a good source of vitamins A, B and D.

Soybean is a member of Papilionaceae family and believed to have originated in North Eastern China and distributed in Asia, USA, Brazil, Argentina, *etc.* This crop is also called as “Golden Bean” or “Miracle Crop” of the 20th century, because of its multiple uses. In addition to the nutritional advantages, soybean is also recognized for its benefits to human health such as the cholesterol lowering effect of protein as approved recently by the United States Food and Drugs administration. Research is underway to study the possible benefits of soybean in other areas of human health such as cancer, osteoporosis and postmenopausal discomfort. Above all, the greatest potential of soybean lies in increasing the available food supply for the rapidly increasing population in the 21st century (Wilmot, 2001).

Soybean constitute a major role in the total world production of oilseeds and figures around 250-255 million tones. The major soybean producers are US, China, Brazil, Argentina and India. According to the increase in the world consumption of meat, the demand for soybean is also increasing as it serves as a good feed for

livestock. World production of soybean for 2010- 2011 was projected at 253.6 million tons. Among all the soybean producing countries, US occupy the prime position contributing nearly 37% of total world production followed by Brazil and Argentina. Soybean production in India accounts for only 3% of total production in the global market.

The soybean crop is grown mainly in the states of Madhya Pradesh, Maharashtra and Rajasthan. However, Madhya Pradesh constitute major role in total soybean production. During the year 2010-2011 the area sown under soybean came down compared to previous year due to late arrival of monsoon. In India 8,800 thousand metric tones is the estimated domestic output from 9000 million hectares in 2010-2011 against 8,750 thousand metric tons in 2009-2010.

India is one of the major exporters of soy meal to the Asian countries. Being one of the most popular protein meals in the world it is estimated that the export of soy meal from India is likely to be 3.2 million tons in 2010-2011 against 2.6 million tons in 2009-2010, (Anonymous 2011).

Plant breeding essentially involves improvement of crops to suit the needs of man. The extent of improvement depends upon the variability available or generated and the efficiency of selection schemes. The development of superior variety can be based on the magnitude of genetic variability in the base material and the extent of heritability of desirable characters. To begin with any crop improvement programme the information of genetic variability in genetic system of particular crop is sought as pre-requisite. Although increased seed yield is the ultimate aim of the plant breeders, seed yield itself is a product of interaction of many component traits which influence it directly or indirectly. Therefore, variability existing within each component trait must be exploited by selection to realize maximum gain in seed yield (Gohil *et al.*, 2006a).

Collection of germplasm and assessment of genetic variability is a basic step in any crop improvement programme. Yield being a complex character, is influenced by a number of yield contributing characters controlled by polygenes and also influenced by environment. So, the variability in the collections for these characters is the sum total of heredity effects of concerned genes plus the influence of the environment. Hence, it becomes necessary to partition the observed variability into heritable and non-heritable components measured as genotypic and phenotypic coefficients of variation (GCV and PCV), heritability and genetic advance expressed as per cent mean. The development of superior variety can be based on the magnitude of the base material and the extent of heritability of desirable characters (Dhillon *et al.*, 2005).

However, inheritance of quantitative characters is often influenced by variation in other characters which may be due to pleiotrophy or genetic linkage (Harland, 1939). Hence, knowledge of association between yield and its components obtainable through estimation of genotypic and phenotypic correlations helps a great deal to formulate selection. Correlation coefficient (r), measures only the degree (intensity) and nature (direction) of association between characters. Regression coefficient (b), quantifies the rate of change independent variable for unit change in the independent variable.

In soybean, grain yield, as in other crops, is a complex character, which is dependent on a number of variables. To increase its yield, the study of direct and indirect effects of yield and its components provide the basis for its successful breeding programme and thus increase of soybean yield can be more effectively tackled on the basis of performance of yield components and selection for closely associated traits. Path co-efficient analysis measures the direct and indirect effect

for one variable upon another and permits the separation of the correlation coefficient into components of direct and indirect effect.

Therefore, the knowledge of genetic makeup, overall genetic variability, the magnitude of heritable and non heritable component is essential for developing suitable breeding programme.

Hence, the present study on “Genetic variability, correlation and path analysis studies for seed yield and yield contributing characters in soybean (*Glycine max* (L.) Merrill)” was undertaken with following objectives.

1. To study the pattern of genetic variability.
2. To study the correlation and path analysis for seed yield and yield contributing characters.

REVIEW OF
LITERATURE

Chapter-II

REVIEW OF LITERATURE

Literature on genetic variability, heritability and genetic advance, correlation and path analysis is referred in following sections.

2.1 Genetic variability:

The magnitude of genetic variability in the breeding material determines the speed and precision of the improvement programme in a particular crop. A population with higher variability provides greater opportunity for improvement.

Several reports on genetic variability in soybean are available. However, only few of them are reviewed here.

Taware *et al.* (1995) analyzed the variance for six characters and observed highly significant differences among varieties. The result indicated high amount of phenotypic variability. 100 seed weight recorded highest value for heritability followed by days to flower, days to maturity and seed yield. High amount of heritability combined with high values of genetic gain for 100 seed weight revealed its importance in soybean.

Singh *et al.* (1996) observed wide range of variability for all the characters studied. Genotypic coefficient of variation was high for plant height, number of primary branches per plant, number of pod bearing nodes per plant, seed yield per plant and biological yield per plant. Number of pods per plant, number of pod bearing nodes per plant had relatively high coheritability value with grain yield per plant.

Singh and Singh (1999) reported high genotypic and phenotypic coefficient of variation for grain yield, pods per plant, 100 seed weight and days to flowering. Heritability estimates were high for days to flowering and days to maturity. Genetic advance was high for plant height, pods per plant, grain yield and days to flowering.

Bhandarkar (1999) observed a high genetic coefficient of variation for plant height, seed yield per plant, number of primary branches and mature pods per plant, which indicated further scope for improvement in these traits. High heritability was observed for days to initial flowering, days to 50 per cent flowering, plant height, 100 seed weight, days to maturity and number of primary branches. Moderate heritability was observed for mature pods per plant and seed yield. High heritability and genetic advance as percent of mean for plant height, 100 seed weight, days to initial flowering, days to 50 percent flowering, number of primary branches and days to maturity showed the possibilities of improvement of these traits contributing to yield.

Jain and Ramgiry (2000) recorded high phenotypic and genotypic coefficient of variability for seed yield per plant followed by plant height, plant weight and moderate coefficient of variability for 100 seed weight, seed per pod and days to flowering. High heritability estimates accompanied by high genetic advance as a percentage of mean were noticed for seed yield, plant height and pods per plant.

Singh and Yadava (2000) estimated that the genotypic coefficient of variation and phenotypic coefficient of variation was comparatively high for seed yield per plant, pods per plant and plant height. The characters seed yield per plant, pods per plant and plant height exhibited high estimates of heritability with high genetic advance as percentage of mean.

Agarwal *et al.* (2001) reported that genetic variability parameters like GCV, PCV, heritability and genetic advance for plant growth characters and indicated high GCV for degree of indeterminate growth habit, plant height and branches per plant. Estimates of GCV were moderate for days to flower initiation, whereas low for days to maturity. Heritability and genetic advance as percentage of mean were high for all the plant growth characters.

Dixit *et al.* (2002) studied 38 newly developed genotypes of soybean and observed that seed yield per plant, harvest index and biological yield per plant showed comparatively high estimates of genetic variation and heritability. Hence direct selection for these traits would be effective for yield improvement.

Bangar *et al.* (2003) observed that the values of PCV were higher than GCV. The GCV and PCV estimates were highest for number of branches per plant and plant height among the characters. The GCV and PCV were of moderate magnitude for the number of pods per plant, 100 seed weight and seed yield per plant. Days to 50 per cent flowering and days to maturity had very low GCV and PCV estimates. The difference between GCV and PCV were very high for 100 seed weight and number of pods per plant. Days to maturity, number of branches per plant and plant height showed the highest magnitude of heritability. Genetic advance was high for number of branches per plant, plant height and seed yield.

Dhillon *et al.* (2005) observed that most of the characters possessed sufficient genetic variability. High heritability was accompanied by high genetic advance for seed yield per plant indicating the presence of additive gene action in the expression of this character. Non additive heritability was observed in the expression of the days to 50 per cent flowering, protein content and palmitic acid as these traits had high heritability estimates accompanied by low genetic advance.

Karad *et al.* (2005) revealed phenotypic coefficient of variation was higher than genotypic coefficient of variation for all the characters indicating modifying effects of environment on expression of characters under study. The estimates GCV were high for yield per plot, plant height and number of pods per plant, while they were moderate for number of seeds per pod, number of branches per plant indicating that these yield contributing characters have scope for improvement by selection.

Sahay *et al.* (2005) noticed high heritability and genetic advance for plant height, number of unfilled pods, seed weight per plant, number of pods per plant, number of pod clusters and 100 seed weight.

Vart *et al.* (2005) reported that the phenotypic coefficient of variation was slightly higher than the genotypic coefficient of variation. Heritability was high for all the characters, where as expected genetic gain in terms of percentage of mean was highest for clusters per plant and lowest for days to maturity. Traits with high heritability and high genetic advance also had moderate to high genotypic and phenotypic coefficient of variation.

Gohil *et al.* (2006a) observed genetic variability, broad sense heritability and expected genetic advance for seed yield and its component traits. The highest GCV was observed for number of pods per plant followed by seed yield per plant. Plant height, number of clusters per plant, number of pods per plant and seed yield per plant had high genetic advance coupled with high heritability which suggested that these four traits are under the control of additive gene action and can be improved through simple selection procedures.

Malik *et al.* (2006) reported high heritability for 100 grain weight, number of days to maturity, number of days to flowering completion, number of days to 50

per cent flowering, oil content, grain yield per plant and plant height indicating additive type of gene action governing the traits.

Troung *et al.* (2006) evaluated the genetic diversity for reproductive growth characters in exotic germplasm resources and observed wide range of phenotypic variation for number of pods per plant and seed yield per plant. Korean cultivar showed greater diversity than the exotic cultivars.

Gupta and Punetha (2007) studied genotypic and phenotypic variability, heritability and genetic advance in 12 quantitative traits including seed yield per plant and main seed vigour. Pods per plant exhibited the highest amount of genetic variability followed by seed vigour, seed yield per plot, seeds per pod and 100 seed weight. Pods per plant also expressed the highest heritability and expected genetic advance.

Sharma *et al.* (2007) estimated that the PCV ranged between 3.19 percent for protein content and 55.45 for grain yield per plant. Maximum GCV was found for grain yield per plant and minimum for protein content. Estimated maximum heritability for number of seeds per plant, high to moderate heritability for the number of pods per plant, number of primary branches per plant, 100 seed weight, days to flower initiation, days to 50 per cent flowering and oil percentage was reported.

Sirohi *et al.* (2007) recorded the data for days to 50 per cent flowering, days to maturity, plant height, number of primary branches, number of pods per plant, seed yield per plant, seed weight and harvest index. The estimates of genotypic coefficient of variation ranged from 3.33 for pod width to 38.13 for number of pods per plant and the estimates of GCV were high for number of pods per plant,

number of clusters per plant, seed yield per plant, plant height and biological yield per plant.

Yadav (2007a) observed that seed yield per plant, number of pods per plant and plant height exhibited maximum genotypic coefficient of variation. High heritability coupled with high genetic advance as percentage of mean was noted for plant height, pods per plant and seed yield per plant. Significant contribution of additive genetic variance was observed for all characters. Coheritability was high for character like seed yield per plant with all characters. Hence, selection for these characters might be as effective as direct selection.

Ramteke *et al.* (2010) revealed information on the economic characters from ninety two varieties of soybean. Analysis of variance was carried out for the data recorded on plant height, nodes plant⁻¹, branches plant⁻¹, 100-seed weight, days to 50 % flowering, days to maturity, grain yield, oil and protein content. Results revealed highly significant differences among varieties for all the characters. High heritability was recorded for days to maturity, days to 50 % flowering, plant height, nodes, oil and protein content, indicating the additive mode of gene action.

Aditya *et al.* (2011) studied genetic parameter and correlation of eight quantitative traits including grain yield in thirty one soybean genotypes. Among all the traits, seed yield per plant exhibited highest estimate of PCV and GCV followed by dry matter weight per plant and number of pods per plant. Heritability was highest for three characters i.e., days to 50 per cent flowering, number of primary branches per plant and 100 seed weight. High heritability coupled with high genetic advance was recorded for number of pods per plant and dry matter weight per plant. Grain yield per plant exhibited highly significant and positive genetic correlation with dry matter weight per plant, number of primary branches per plant, number of pods per plant and harvest index.

Khan *et al.* (2011) revealed that all the characters like days to flowering, days to pod formation, days to maturity, plant height (cm), branches/plant, pods/plant, pod length (cm), seeds/pod, 100 grain wt (g) and yield (g/plant) were significantly affected due to various soybean genotypes. The genotypes Zane, Black hack, Bragg and Menlin remained the best among 20 lines studied in term of bearing pods, high grain weight and yield production. It was suggested that these superior lines may be focused and involved in future breeding programme for development of new high yielding soybean varieties.

Patil *et al.* (2011) observed highest genotypic and phenotypic coefficient of variances for plant height followed by seed yield per plant and pods per plant and it was lowest for days to 50 per cent flowering, days to maturity, protein content and pod length. High heritability and genetic advance were observed for plant height, seed yield per plant and pods per plant.

2.2 Correlation and Path Analysis:

Correlation coefficient measures the intensity of association between two characters. Association analysis between quantitative characters is important because it indicate the change brought out in them when selection pressure applied on one character even though the other character is not subjected to any selection. The measured relationship is vital in planning the efficient breeding programme for improvement of one or more economic characters which are known to be dependent on two or more metric traits.

Johnson *et al.* (1955) evaluated two populations of F_3 lines of soybean in F_4 generation. He reported that genetic correlation among characters for which selection is practiced may have important implication in breeding procedures, they

pointed out that selection for yield in soybean is different and requires more replications over years, locations and individual tests are required for selection of other important characters.

Dewey and Lu (1959) evaluated 81 progenies of crested wheat grass during 1955 and 1957 and calculated genotypic and phenotypic correlation coefficient for all combinations between seed size, spikelet per spike, fertility, seed weight per spike, and seed yield. The phenotypic and genotypic correlations agreed closely. High genotypic correlations were found for fertility and plant size. He used the method of path coefficient into their components which showed that fertility and plant size were the factors existing the greatest influence both direct and indirect on seed yield.

Jadhav *et al.* (1995) observed correlation and path analysis for number of branches per plant, pods per plant, seeds per plant, days to maturity, pod length and pod weight per plant and showed that these traits were positively, highly and significantly correlated with seed yield.

Taware *et al.* (1995) reported that the seed yield was positively correlated with days to flower and maturity as well as pod per plant. Days to flower and maturity, plant height and pod per plant were positively and significantly correlated with each other. Path analysis revealed that highest positive direct effect of days to maturity followed by pods per plant and days to flower.

Shukla *et al.* (1998) indicated that seed yield was significantly correlated with number of pods per plant. Significant and positive correlation was also observed between plant height and pods per plant. Path analysis indicated that harvest index had both direct and indirect effects on seed yield.

Sharma and Phul (1999) indicated that nodule number per plant and pods per plant had significant positive and direct effect on grain yield and are the important yield components. Further nodule weight per plant and 100 seed weight in conjunction with nodule number per plant and pods per plant should also be considered during selection for improvement in grain yield.

Singh and Singh (1999) revealed that the grain yield exhibited significant and positive association of branches per plant, pods per plant and 100 seed weight. Path analysis revealed that pods per plant and 100 seed weight had high direct and positive effect on grain yield.

Thorat *et al.* (1999) carried out the path analysis and showed the number of pods had a large effect on yield. Days to 50 per cent flowering had a positive and significant correlation with seed yield. However its indirect effect via number of pods was substantial. Indirect effect of plant height via number pods also high. Therefore, breeding for high yield could be based on maximum number of pods per plant and number of seeds per pod.

Rajanna *et al.* (2000) revealed that significant and positive correlation for number of pods per plant and 100 seed weight with seed yield. Days to maturity, plant height and number of branches per plant exhibited significant and positive correlation with number of clusters per plant and number of pods per plant. Path analysis revealed higher direct effects of number of pods per plant and 100 seed weight on seed yield per plant. All the characters exhibited higher indirect effects via number of pods per plant on seed yield showing its importance in determining seed yield.

Rezaizad *et al.* (2001) studied the correlation analysis showed that number of seeds per plant and seed yield per plant had the highest significant correlation

coefficient. Other significant correlation coefficients were found between biomass per plant and yield and between number of pods and yield. Path analysis showed that number of seeds per plant and seed weights were important for soybean selection programmes. Path analysis revealed that the correlation effects to plant height and number of days to 90 per cent maturity on yield was due to indirect effects through other traits.

Zeinali *et al.* (2002) evaluated the genetic correlation between seed oil and some important agronomic traits in soybean and showed that genetic correlation for 100 seed weight; flowering date and maturity date had significant negative correlation, while number of seeds per pod had significant positive correlation with oil percentage. Results of path analysis showed that increase in oil percentage was primarily due to decrease in protein percentage. Flowering and maturity dates had also direct and negative effects on oil percentage.

Bangar *et al.* (2003) indicated that correlation coefficient for seed yield was positively and significantly correlated with 100 seed weight and followed by days to maturity, plant height and days to 50 per cent flowering. Days to maturity, pods per plant and 100 seed weight among themselves were positively significant.

Chettri *et al.* (2003) reported that grain yield was significantly correlated with days to maturity and number of grains per pod at the genotypic level. Days to maturity and number of grains per pod were also correlated. Days to maturity was significantly correlated with plant height and days to 50 per cent flowering at the phenotypic and genotypic levels. The number of days to fifty per cent flowering was positively and significantly correlated to days to fifty per cent flowering but negatively with number of pods per plant and 100 grain weight at the genotypic level. The 100 grain weight did not show correlation with grain yield. Path

coefficient estimates showed that the number of grains per pod, days to maturity, number of pods per plant and plant height positively affected grain yield.

Iqbal *et al.* (2003) revealed that seed yield per plant was positively and significantly associated with all parameters studied. The result also showed that pods per plant have maximum positive effect on yield per plant. It was followed by 100 seeds per pod. Plant height had negative direct effect per plant. It was concluded that pods per plant, seeds per pod, and 100 seed weight were the main yield components.

Oneml (2003) observed that plant yield showed positive and significant correlations with number of pods, number of branches, pod length and 1000 seed weight. The correlation between seed yield per plant and lowest pod height were significantly negative. The number of pods maintained positive and significant correlation with plant height, number of branches and 1000 seed weight while negative correlations with lowest pod height.

Bizeti *et al.* (2004) studied the correlation and path analysis in soybean and showed that the seed size was not important for increased yield. The number of nodes and plant height at maturity showed significant correlation with grain yield. Number of nodes at maturity trait had high direct effect on grain yield per plant.

Mukhekar *et al.* (2004) observed that the seed yield was significantly and positively associated with number of pods per plant, days to 50 per cent flowering, mean internodal length, plant height, days to maturity and number of branches per plant. Pods per plant had highest direct as well as final contribution towards seed yield and can be considered as most reliable yield indicator in soybean.

Vart *et al.* (2005) reported that magnitude of correlation coefficients at the genotypic level was higher than the corresponding phenotypic level, thereby

indicating strong inherent association between these characters. The overall results indicated that significant positive correlations with seed yield were due to relationship between biological yield and pods per plant and hence referred as the most cordial component of yield.

Bhairav *et al.* (2006) carried out correlation and path analysis using 198 germplasm lines of soybean for 8 component characters including seed yield both at genotypic and phenotypic level. Pods per plant, 100 seed weight and plant height had positive and significant correlation with seed yield. Path analysis showed positive and high direct effect of biological yield per plant and harvest index and indirect effect of other component characters through these characters towards seed yield per plant.

Gohil *et al.* (2006b) indicated that genotypic correlation coefficient were higher in magnitude than their corresponding phenotypic correlation coefficient for most of the traits. Seed yield per plant showed significant and positive association with plant height, branches per plant, clusters per plant, pods per plant and 100 seed weight and only negatively correlated with oil content and protein content at both levels. Pods per plant showed significant and positive association with plant height and branches per plant. Days to 50 per cent flowering and days to maturity showed significant and positive correlation with each other. The path analysis indicated that the number of pods per plant had maximum direct effect on seed yield followed by 100 seed weight and number of clusters per plant. This appeared to be major yield contributing traits in soybean.

Muhammad *et al.* (2006) reported that grain yield had positive and significant correlation with days to maturity, number of branches, number of pods and 100 seed weight. Days to maturity, number of branches, number of pods and

100 seed weight had positive direct effects on grain yield. High indirect effect was also exhibited via pod length by most of the traits.

Saharan *et al.* (2006) revealed that seed yield per plant was positively correlated with number of pods per plant, number of branches per plant, 100 seed weight and protein content. Oil content did not show any correlation with seed yield.

Truong *et al.* (2006) estimated the correlation analysis and showed that days to flowering and days to maturity had close association with agronomic traits as well as yield and yield components. Both days to flowering and days to maturity had positive correlation with the other characters except 100 seed weight.

Gaikwad *et al.* (2007) reported the genetic correlation was greater than the phenotypic correlation. The number of pods per plant showed the positive and significant correlation with seed yield per plant. Path analysis revealed that harvest index, number of pods per plant, and pod length had the greatest direct effects on seed yield per plant. The number of pods per plant and harvest index was the important component character to be considered during selection for increased seed yield in soybean.

Malik *et al.* (2007) reported that genotypic correlations were higher than the phenotypic and environmental ones for most of the characters exhibiting high degrees of genetic association among the traits under consideration. Correlation coefficient for yield was positive with days to flowering, days to maturity, plant height and number of branches per plant. Path coefficient analysis revealed that days to flowering completion had maximum direct contribution to yield followed by number of pods per plant and plant height.

Narjesi *et al.* (2007) reported that number of pods per plant, number of seeds per plant and 100 seed weight, all of which are considered yield components, had the highest genotypic correlation with seed yield. Path analysis showed that harvest index and protein percentage had the highest and lowest direct and positive effect respectively.

Sirohi *et al.* (2007) observed that seed yield showed positive and significant association with days to 50 per cent flowering, number of pods per plant, days to maturity, plant height and biological yield per plant. Path analysis showed that biological yield had the highest positive direct effect of contribution towards seed yield.

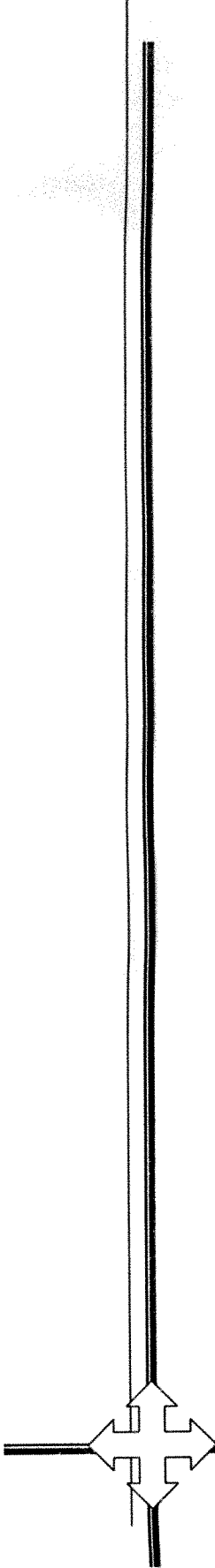
Yadav (2007b) studied the 10 characters, days to 50 per cent flowering, days to maturity, plant height, pod bearing length, pod number per plant, seed number per plant, 100 seed weight, protein content, oil content, and genetic correlation for seed yield. Results indicated that seed yield was significantly correlated with height, pod bearing length, number of pods per plant and number of seeds per plant.

Ramteke *et al.* (2010) observed that correlation coefficient of yield was significantly negative with days to flowering and maturity. Seed weight was negatively correlated with days to flowering, maturity, plant height, nodes but positively with oil content. Protein content, however, was positively correlated with number of branches and days to 50% flowering but negative with oil content.

Showkat and Tyagi (2010) estimated correlation and path coefficient analysis for seed yield and its components in 40 genotypes of soybean. The studies indicated that out of 16 characters, seed yield showed positive and significant association with biological yield, days to maturity, branches per plant, harvest index, pod filling period, pods per plant, 100 seed weight and clusters per plant

indicating that an intense selection for these characters improve seed yield in soybean. Path coefficient analysis revealed that biological yield and harvest index were major characters influencing seed yield directly and indirectly. The results indicated that biological yield is responsible for manipulation of seed yield in soybean.

Mudibu *et al.* (2011) observed that plant height, stem diameter at first internodes and number of leaves per plant were significantly correlated to each other. Significant correlation was also observed between leaflet length and plant height. Grain yields were highly and significantly correlated to the number of pods and seeds per plant. Based on grain yield and disease resistance over the two years of trials at different locations, ten accessions have been identified as adapted to the local conditions of the main growing soybean region in the DR-Congo.



MATERIAL AND METHODS

Chapter III

MATERIAL AND METHODS

The present investigation was undertaken to study “Genetic variability, correlation and path analysis studies for seed yield and yield contributing characters in soybean (*Glycine max* (L.) Merrill)”.

3.1 EXPERIMENTAL MATERIAL

The experimental material comprised of 30 soybean genotypes including three check varieties. The experimental material consists of advanced lines were obtained from AICRP on soybean, MKV, Parbhani. The details of advanced lines studied in present investigation are given in table No. 1.

3.2 EXPERIMENTAL LOCATION

The present experiment was carried out at experimental farm of Department of Agricultural Botany, College of Agriculture, Latur during *kharif* season 2011.

3.3.1 EXPERIMENTAL DETAILS

1. No. of entries	: 27+3
2. Experimental design	: RBD
3. No. of replications	: 3
4. No. of rows/plot	: 4
5. Spacing	
a) Row to row distance	: 45 cm
b) Plant to plant distance	: 5 cm
6. Row length	: 3 m
7. Fertilizer dose (Kg/ha)	: 30 N: 60 P
8. Date of sowing	: 10 th July, 2011

Table No. 1: List of genotypes and checks tested.

Sr. No.	Genotypes	Sr. No.	Genotypes
1	MAUS 423	16	AMS 99-33
2	MAUS 427	17	MACS 1140
3	MAUS 453	18	MACS 1188
4	MAUS 521	19	MACS 1281
5	MAUS 449	20	MACS 1259
6	MAUS 348	21	KDS 378
7	MAUS 71	22	KDS 384
8	MAUS 81	23	KDS 638
9	MAUS 158	24	KS 103
10	MAUS 162	25	KS 106
11	MAUS 47	26	KS 112
12	MAUS 61-2	27	JS 97-92
13	AMS 243	28	JS 93-05 (c)
14	AMS-MB 5-18	29	JS 335 (c)
15	AMS-MB 5-19	30	BRAGG (c)

3.3.2 CULTURAL PRACTICES

Recommended agronomical and plant protection practices were followed regularly. The crop was given fertilizer dose of 30 N: 60 P (Kg/ha) at the time of sowing. All the recommended intercultural operations were carried out to keep the field clean and free from weeds.

3.4 OBSERVATIONS RECORDED

Five plants were selected randomly from each four row plot and from each replication for recording the observations. Average value of the genotype for each character was computed from these plants. Following observations were recorded.

3.4.1 Days to first flowering

Number of days from sowing to first flowering was recorded and average number of days to first flowering was worked out.

3.4.2 Days to 50 per cent flowering

Number of days taken from the date of sowing to the day on which 50 per cent of the plants in each entry initiate first flower was recorded as days to flowering.

3.4.3 Days to maturity

Number of days taken from date of sowing to physiological maturity of the plant was recorded as days to maturity.

3.4.4 Plant height (cm)

Height of the main stem from the ground level to the top of the main stem was measured in centimeters at the time of harvesting.

3.4.5 Number of branches per plant

This was recorded by counting the total number of branches present on main stem of each selected plant at the time of harvest.

3.4.6 Number of pods per plant

This was recorded by counting the number of pods present on main stem and branches in each of the five selected plants.

3.4.7 100-seed weight (g)

100-seed weight was computed by weighing 100 seeds which are randomly chosen from a complete sample made by mixing the seeds of all the five plants in each replication and recorded in grams.

3.4.8 Oil content (%)

Oil content in seed sample of each genotype of three replications was estimated by using Nuclear Infrared Reflectance (NIR).

3.4.9 Seed yield per plant (g)

The total seeds obtained from each of the randomly selected plant were weighed in grams.

3.5 STATISTICAL METHOD

3.5.1 Analysis of variance

The mean value of all the genotypes for the characters under study was worked out. Standard error and critical difference at 1 and 5 per cent level of significance was calculated by using the formula (Panse and Sukhatme, 1955).

	d. f.	M.S.	Expected mean square
Replications	(r-1)	MS ₁	$\delta^2 e + g \delta^2 r$
Genotypes	(g-1)	MS ₂	$\delta^2 e + r \delta^2 g$
Error	(r-1) (g-1)	MS ₃	$\delta^2 e$

Where,

r = number of replication

g = number of genotypes

δ^2_e = error variance

δ^2_g = genotype variance

δ^2_r = replication variance

$$1. \quad \text{Standard error (S.E.)} = \frac{\sqrt{EMSS}}{\sqrt{r}}$$

Where,

EMSS = Error Mean Sum of Square

r = Number of replication

Critical difference (C.D.) = S.E. $\times \sqrt{2} \times t$ value at 5 % level of error
degrees of freedom

3.5.2 Genetic variability

Various parameters of genetic variability were calculated by using the following formula

- $$\text{Treatment MSS} - \text{Error MSS}$$
- i. Genotypic variance (δ^2_g) = $\frac{\text{Treatment MSS} - \text{Error MSS}}{\text{No. of replications}}$
 - ii. Phenotypic variance (δ^2_p) = (Genotypic variance + error variance)

The genotypic and phenotypic coefficient of variation (GCV and PCV) were calculated by (Burton, 1952)

$$\begin{aligned}
 1. \text{ Genotypic coefficient of variation (GCV)} &= \frac{\sqrt{\delta^2 g}}{\bar{X}} \times 100 \\
 2. \text{ Phenotypic coefficient of variation (PCV)} &= \frac{\sqrt{\delta^2 p}}{\bar{X}} \times 100
 \end{aligned}$$

Where,

$\delta^2 g$ = Genotypic variance

$\delta^2 p$ = Phenotypic variance

$\bar{X}$ = General mean of character

3.5.3 Heritability and genetic advance

Heritability (broad sense) was calculated according to the method suggested by Allard (1960).

$$1. \text{ Heritability (h}^2\text{) B.S.} = \frac{\delta^2 g}{\delta^2 p} \times 100$$

Where,

$\delta^2 g$ = genotypic variance

$\delta^2 p$ = phenotypic variance

The genetic advance at 5 per cent selection intensity was calculated for each character using the formula suggested by Johnson *et al.*, (1955).

$$2. \text{ Genetic advance (G.A.)} = K. \delta p. h^2$$

Where,

K = selection differential at 5% level i.e. 2.06

δp = Phenotypic standard deviation

h^2 = heritability

The expected genetic advance in percentage of mean was calculated as,

GA

$$3. \quad EGA = \frac{\text{GA}}{\bar{X}} \times 100$$

Where,

EGA = expected genetic advance

GA = genetic advance

$\bar{X}$ = general mean of character

3.5.4 Correlation

Covariance was calculated for all the characters to find out correlation among the characters. The inter relationship of different yield contributing characters was worked out according to Johnson *et al.*, (1955).

$$r = \frac{\text{Cov. (x. y.)}}{(\delta^2 x \delta^2 y)^{1/2}}$$

Where,

r = correlation coefficient between the characters x and y

Cov. (x. y.) = covariance between x and y.

$\delta^2 x$ and $\delta^2 y$ are the respective variances of x and y.

The significance of correlation coefficient was tested against 'r' value given by Fisher and Yates (1963) at (n-2) degrees of freedom at 5 and 1 % level of significance.

3.5.5 Path coefficient analysis

Path coefficient analysis was carried out according to Dewey and Lu (1959). The direct and indirect path coefficients were calculated by solving the following set of 'p' simultaneous equations by the abbreviated Doolittle technique.

$$P_{01} + P_{02} r_{12} + \dots + P_{0p} r_{1p} = r_{01}$$

$$P_{01} r_{12} + P_{02} + \dots + P_{0p} r_{2p} = r_{02}$$

$$P_{01} r_{1p} + P_{02} r_{2p} + \dots + P_{0p} = r_{0p}$$

Where,

$P_{01}, P_{02}, \dots, P_{0p}$ are the path effects of 1, 2, ..., p variable on 'o' variable.

$r_{12}, r_{13}, \dots, r_{1p}, \dots, r_{p(p-1)}$ are the possible correlation coefficient between various independent variables and $r_{01}, r_{02}, \dots, r_{0p}$ are the correlation of the independent variables with dependent variables. The different effects of 'i'th variable via 'j'th variable were worked out as $(P_{0j} \times P_{ij})$. From the simultaneous equations it is clear that the correlation coefficient is the sum of direct and indirect path coefficients.

Residual effect was calculated as under

$$P^2_{OX} = 1 - (P^2_{01} + 2P_{01}P_{02}r_{12} + 2P_{01}P_{03}r_{13} + \dots)$$

$$P^2_{O2} = 2P_{01}P_{03}r_{23} + \dots + P^2_{0p}$$

$$\text{Residual factor} = P^2_{0p}$$

and then averaged.

RESULTS

Chapter IV

RESULTS

The analysis of variance showed significant differences among the genotypes for all characters studied (Table 3). Mean data on genotypes were analyzed as per standard procedure and are presented under the following major heading.

1. Mean performance
2. Genetic variability
3. Correlation
4. Path analysis

4.1 Mean performance:

The mean performance of 27 genotypes and 3 checks under study for nine characters are given in table: 4

4.1.1. Days to first flowering:

The days to first flowering ranged from 33.66 days to 42.66 days with mean of 37.73 days. Among the genotypes MAUS-449 depicted the lowest value 33.66 days for days to first flowering indicating earliness. The thirteen genotypes MAUS-453(35.33 days), MAUS-71 (36.33 days), MAUS-158 (35.33 days), MAUS-47 (36.33 days), AMS-243 (35.00 days), AMS-MB-5-18 (36.33 days),AMS-99-33 (36 days), MACS-1140 (35.66 days), MACS-1188 (36.66 days), MACS-1281 (35.00 days), MACS-1259 (36.33 days), KS-103 (36.66 days) and KS-106 (36.33 days) required less number of days to flowering than all three checks viz. JS-93-05 (37.33 days), JS-335 (37.33 days) and BRAGG (39.00 days).

Table 3: Analysis of Variance for different characters in Soybean

Source of Variation	D.F.	Days to first flowering	Days to 50% Flowering	Days to maturity	Plant Height (cm)	Number of branches per plant	Number of pods per plant	100 seed weight (g)	Oil content %	Seed yield per plant (g)
Replication	2	0.011	0.14	83.81	53.4	0.011	61.56	2.48	29.69	24.16
Treatment	29	16.37**	17.05**	166.00**	557.7**	2.21**	919.21**	8.02**	11.07**	45.40**
Error	58	0.26	0.35	7.62	3.29	0.046	3.47	2.12	2.78	6.53

*, ** : significant at 5 and 1 per cent level, respectively

The genotype MAUS-162 and MAUS-348 (42.66 days) showed the highest value for the days to first flowering.

4.1.2. Days to 50% flowering:

The range of days to 50% flowering was ranged from 36.66 days to 46.66 days with general mean of 41.78 days. Among the genotypes MAUS-449 (36.66 days) had shown the earliest values for days to 50% flowering, while the genotype MAUS-348 (46.66 days) recorded highest value for days to 50% flowering.

The fourteen genotypes MAUS-453 (38.33 days), MAUS-71(39.33 days), MAUS-158 (38.33 days), MAUS-47 (39.66 days), AMS-243 (38.00 days), AMS-MB-5-18 (40.33 days), AMS-99-33 (39.00 days), MACS-1140 (39.66 days), MACS-1188 (39.66 days), MACS-1281 (39.00 days), MACS-1259 (40.66 days), KS-103(40.00 days), KS-106 (40.00 days) and JS-97-92 (40.66 days) required less number of days to 50% flowering than the all three checks JS-93-05 (42.33 days), JS-335 (41.00 days) and BRAGG (43 days).

4.1.3. Days to maturity:

It ranged from 83.66 days to 104 days with the general mean of 94.84 days. Seven genotypes MAUS-453 (88.66 days), MAUS-521 (88.66 days), MAUS-449 (88.00 days), MAUS-47 (83.66 days), MAUS-61-2 (89.00 days), KS-112 (90.66 days), JS-97-92 (90.33 days) matures earlier than the all three checks JS-93-05 (92.66 days), JS-335 (96.00 days) and BRAGG (91.00 days).

The genotype AMS-MB-5-19 (104 days) showed the highest value for days to maturity indicating the late maturity.

4.1.4. Plant height (cm):

There was wide range of variation for plant height ranging from 36.10 cm to 90.32 cm with general mean of 61.11 cm. The highest plant height was recorded by genotype MAUS-453 (90.32 cm) while the genotype JS-97-92 (36.10 cm) showed lowest value among the all genotypes and checks.

The check JS-93-05 (89.70) showed the higher plant height than other two checks JS-335 (58.66 cm) and BRAGG (53.80 cm).

4.1.5. Number of branches per plant:

The number of branches ranged from 2.60 to 5.73 with general mean of 3.93. The numbers of branches per plant were highest in genotype KDS-638 (5.73) followed by MACS-1188 (5.66), MAUS-348 (5.06), MACS-1259 (4.80), MAUS-158 (4.80) and significantly superior over the checks JS-93-05 (4.60), JS 335 (4.20) and BRAGG (4.46).

The lowest number of branches observed in genotype MAUS-81 (2.60) and MAUS-162 (2.60) followed by genotype MAUS-71 (2.66), MAUS-453 (2.93) and MAUS-61-2 (3.00).

4.1.6. Number of pods per plant:

There was wide range of variation for number of pods per plant ranging from 33.46 to 99.60 with general mean of 54.26. The highest number of pods noted in genotype KS-112 (99.60), while the lowest number of pods observed in genotype AMS-243 (33.46).

The fourteen genotypes showed higher number of pods per plant than three checks JS-93-05 (41.40), JS-335 (46.30) and BRAGG (43.90).

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Table 4: Mean performance of genotypes for yield and yield contributing characters in Soybean

Sr. No.	Genotype	Days to first flowering	Days to 50% Flowering	Plant Height (cm)	Days to maturity	Number of branches per plant	Number of pods per plant	100 seed weight (g)	Oil content %	Seed yield per plant (g)
1.	MAUS 423	38.33	41.33	52.86	95.66	3.73	42.00	14.33	20.00	18.90
2.	MAUS 427	40.66	43.33	56.33	92.33	4.46	39.53	14.46	20.10	14.33
3.	MAUS 453	35.33	38.33	90.32	88.66	2.93	38.50	12.83	21.74	13.15
4	MAUS 521	38.66	41.66	70.86	88.66	3.80	45.70	14.02	19.00	16.43
5	MAUS 449	33.66	36.66	40.20	88.00	4.46	39.06	9.82	20.90	13.44
6	MAUS 348	42.66	46.66	49.73	97.33	5.06	52.80	12.33	17.50	19.85
7	MAUS 71	36.33	39.33	61.66	96.00	2.66	44.80	11.93	17.70	16.87
8	MAUS 81	41.00	44.00	54.33	91.66	2.60	62.50	11.71	17.33	16.63
9	MAUS 158	35.33	38.33	41.93	96.00	4.80	47.80	13.73	17.80	27.20
10	MAUS 162	42.66	46.00	51.23	96.00	2.60	50.10	12.02	18.80	22.60
11	MAUS 47	36.33	39.66	61.40	83.66	3.80	49.30	14.88	17.90	19.23
12	MAUS 61-2	42.00	45.00	85.12	89.00	3.00	46.20	15.42	20.20	18.73
13	AMS 243	35.00	38.00	64.50	91.66	2.80	33.46	14.15	18.20	13.54
14	AMS-MB 5-18	36.33	40.33	70.40	100.33	3.53	37.60	13.56	17.10	10.75
15	AMS-MB 5-19	37.66	42.00	67.60	104.00	3.26	37.00	13.65	20.60	20.51

Table : 4 Contd...

Sr. No.	Genotype	Days to first flowering	Days to 50% Flowering	Plant Height (cm)	Days to maturity	Number of branches per plant	Number of pods per plant	100 seed weight (g)	Oil content %	Seed yield per plant (g)
16	AMS 99-33	36.00	39.00	64.16	100.33	3.26	36.33	13.54	17.80	14.56
17	MACS 1140	35.66	39.66	54.33	99.33	3.66	64.20	9.32	21.00	14.63
18	MACS 1188	36.66	39.66	61.90	98.66	5.66	85.40	10.63	19.70	18.76
19	MACS 1281	35.00	39.00	58.70	98.33	3.46	63.66	9.68	20.60	16.86
20	MACS 1259	36.33	40.66	54.00	98.00	4.80	62.80	10.23	20.70	16.42
21	KDS 378	38.66	42.66	82.20	103.33	3.66	70.90	11.94	20.10	23.09
22	KDS 384	38.33	41.33	72.86	100.00	4.53	94.00	13.15	17.90	24.46
23	KDS 638	39.66	43.33	44.40	96.33	5.73	65.33	10.86	20.00	19.56
24	KS 103	36.66	40.00	68.60	97.66	3.93	65.60	13.68	19.40	16.04
25	KS 106	36.33	40.00	56.70	93.66	4.33	76.96	10.32	21.00	17.92
26	KS 112	39.00	42.33	58.90	90.66	4.66	99.60	11.66	17.00	23.20
27	JS 97-92	37.66	40.66	36.10	90.33	3.53	45.10	13.02	17.30	14.13
28	JS 93-05	37.33	42.33	89.70	92.66	4.60	41.40	12.15	19.90	16.20
29	JS 335	37.33	41.00	58.66	96.00	4.20	46.30	12.96	17.90	17.74
30	BRAGG	39.00	43.00	53.80	91.00	4.46	43.90	12.79	20.40	13.90
	MEAN	37.73	41.78	61.11	94.84	3.93	54.26	12.49	19.18	17.65
	SE $\pm$	0.029	0.34	1.04	0.48	0.12	1.07	0.84	0.96	1.47
	CD at 5 %	0.82	0.94	2.90	1.5	0.34	2.97	2.32	2.66	4.08

4.1.7. 100 seed weight:

100 seed weight was ranged from 9.32 g to 15.42 g with the general mean of 12.49 g. Among the genotypes highest value for 100 seed weight was found in genotype MAUS-61-2 (15.42 g), while the lowest 100 seed weight was found in genotype MACS-1140 (9.32 g).

The twelve genotypes MAUS-423 (14.33 g), MAUS-427 (14.46 g), MAUS-521 (14.02 g), MAUS-158 (13.73 g), MAUS-47 (14.88 g), AMS-243 (14.15 g), AMS-MB-5-18 (13.56 g), AMS-MB-5-19 (13.65 g), AMS-99-33 (13.54 g), KDS-384 (13.15 g), KS-103 (13.68 g) and JS-97-92 (13.02 g) had shown highest values for 100 seed weight than all three checks and other genotypes.

4.1.8. Oil content (%):

The oil content ranged from 17.00% to 21.74% with the general mean of 19.18%. The highest value for oil content was recorded in the genotype MAUS-453 (21.74%), while the lowest value for oil content was recorded in line KS-112 (17.00%).

The seven genotypes MAUS-453 (21.74 %), MAUS-449 (20.90%), AMS-MB-5-19 (20.60%), MACS-1140 (21.00%), MACS-1281 (20.60%), MACS-1259 (20.70%), KS-106 (21.00%) showed more oil content than three checks JS-93-05 (19.90%), JS-335 (17.90%) and BRAGG (20.40%) and other genotypes.

4.1.9. Seed yield per plant:

Seed yield per plant was ranged from 10.75 g to 27.20 g with general mean of 17.65 g. Among the genotypes, highest seed yield per plant was observed in genotype MAUS-158 (27.20 g) and the lowest value for seed yield per plant was found in genotype AMS-MB-5-18 (10.75%).

Among the checks JS-335 (17.74 g) showed highest seed yield per plant followed by JS-93-05 (16.20 g) and BRAGG (13.90 g).

4.2. Genetic parameters:

The characters under investigation were analyzed for genotypic variance (σ^2_g), phenotypic variance (σ^2_p), genotypic coefficient of variation (GCV), phenotypic coefficient of variation (PCV), heritability (Broad sense), and expected genetic advance as per cent mean (EGA) and are presented in table 5.

4.2.1. Days to first flowering:

Phenotypic variance (5.63) was slightly higher than the genotypic variance (5.36). Similarly the phenotypic coefficient of variation (6.29%) was slightly higher than genotypic coefficient of variation (6.14%) indicated that the major portion of phenotypic variation was contributed by genotypic component, the environment component being less.

The estimates of heritability was high (95.31%) coupled with moderate genetic advance (12.35%) were recorded.

4.2.2. Days to 50% flowering:

The genotypic variance and phenotypic variance for days to 50% flowering was 5.56 and 5.91 respectively. The genetic coefficient of variation (5.72%) was slightly lower than the phenotypic coefficient of variation (5.90%).

Higher estimates heritability (94.06%) coupled with moderate expected genetic advance (11.44%) was found.

Table 5: Parameters of Genetic Variability for yield and yield contributing characters in Soybean

Sr No.	Character	Range	General Mean	Genotypic variance ($\delta^2 g$)	Phenotypic variance ($\delta^2 p$)	GCV %	PCV %	Heritability(%)	Expected genetic advance (%)
1.	Days to first flowering	33.66-42.66	37.722	5.369	5.633	6.142	6.291	95.31	12.35
2.	Days to 50% Flowering	36.66-46.66	41.178	5.567	5.918	5.729	5.907	94.06	11.44
3.	Days to maturity	83.66-104	94.844	23.490	24.347	5.110	5.202	96.48	10.33
4.	Plant Height (cm)	36.10-90.32	61.117	184.812	188.108	22.243	22.441	98.25	45.41
5.	Number of branches per plant	2.60-5.73	3.936	0.723	0.769	21.608	22.285	94.01	43.16
6.	Number of pods per plant	33.46-99.60	54.262	305.243	308.721	32.197	32.380	98.87	65.95
7.	100 seed weight (g)	9.32-15.42	12.496	1.968	4.090	11.225	16.185	48.10	16.03
8.	Oil content %	17.00-21.74	19.186	1.978	2.231	7.330	7.785	88.65	14.21
9.	Seed yield per plant (g)	10.75-27.20	17.655	13.729	15.398	20.987	22.226	89.16	40.82

4.2.3. Days to maturity:

The genotypic variance (23.49) was lower than the phenotypic variance (24.34). The genetic coefficient of variation (5.11%) was slightly lower than the phenotypic coefficient of variation (5.20%). The high values for heritability (96.48%) coupled with low expected genetic advance (10.33%) was observed for this character.

4.2.4. Plant height:

High genotypic variance (184.81) and phenotypic variance (188.10) was observed for this character. The genetic coefficient of variation (22.24%) was slightly lower than the phenotypic coefficient of variation (22.44%). The high values for heritability (98.25%) coupled with high expected genetic advance (45.41%) was recorded.

4.2.5. Number of branches per plant:

The genotypic variance (0.72) and phenotypic variance (0.76) values for number of branches per plant were low. The genetic coefficient of variation (21.60%) was slightly lower than the phenotypic coefficient of variation (22.28%). The high values for heritability (94.01%) coupled with high expected genetic advance (43.16%) was observed for this character.

4.2.6. Number of pods per plant:

High genotypic variance (305.24) and phenotypic variance (308.72) was observed for this character. The phenotypic coefficient of variation (32.38%) was more than the genetic coefficient of variation (32.19%).

The estimates of heritability was high (98.87%) coupled with high genetic advance (65.95%) were recorded.

4.2.7. 100 seed weight:

The genotypic variance (1.96) was lower than the phenotypic variance (4.09). The phenotypic coefficient of variation (16.18%) was more than the genetic coefficient of variation (11.22%). 100 seed weight showed the low value for heritability (48.10%) coupled with moderate expected genetic advance (16.03%) was observed for this character.

4.2.8. Oil content%:

The genotypic variance (1.97) and phenotypic variance (2.23) values for oil content were low. The genetic coefficient of variation (7.33%) was slightly lower than the phenotypic coefficient of variation (7.78%). Higher estimates heritability (88.65%) coupled with moderate expected genetic advance (14.21%) was found for oil content.

4.2.9. Seed yield per plant:

The genotypic variance (13.72) was lower than the phenotypic variance (15.39). The genetic coefficient of variation (20.98%) was slightly lower than the phenotypic coefficient of variation (22.22%). The high values for heritability (89.16%) coupled with low expected genetic advance (40.82%) was observed for this character.

4.3 Correlation coefficient:

The correlation coefficient between seed yield and its components and among the component characters were estimated at genotypic and phenotypic levels. The genotypic (r_g) and phenotypic (r_p) correlation coefficients of nine characters studied are presented in Table 6 and 7 respectively.

The character seed yield was significantly and positively correlated with days to flowering, days to 50% flowering, days to maturity, plant height,

number of branches per plant and number of pods per plant at both genotypic and phenotypic level. There was weak positive correlation of seed yield per plant with 100 seed weight and oil content at both genetic and phenotypic level. Seed yield was negatively correlated with days to maturity and oil content at both genetic and phenotypic level.

Days to first flowering had positive and significant correlation with days to 50% flowering, days to maturity, plant height, number of pods per plant and seed yield per plant, while it had weak positive correlation with 100 seed weight and oil percentage at the genotypic level. Number of pods per plant and number of branches per plant showed weak positive correlation at phenotypic level with days to first flowering.

Days to 50% flowering was significantly and positively correlated with days to first flowering, days to maturity, plant height, number of branches per plant and seed yield per plant at both genotypic and phenotypic level. Days to 50% flowering has weak positive correlation with 100 seed weight, number of pods per plant and oil content.

Days to maturity was significantly and positively correlated with days to first flowering, days to 50% flowering, plant height, number of pods per plant and oil content. While it had positively correlated with number of branches per plant and 100 seed weight.

Plant height was significantly and positively correlated with days to first flowering, days to 50% flowering, days to maturity, number of pods per plant and seed yield per plant. It shows weak positive correlation with number of branches per plant and oil content, while it had showed negative correlation with 100 seed weight at both genotypic and phenotypic level.

Number of branches per plant was significantly and positively correlated with 100 seed weight at both genotypic and phenotypic level, while it was

positively correlated with days to 50% flowering at genotypic level. It was observed weak positive correlation with days to first flowering, days to maturity, plant height, number of pods per plant, oil content and seed yield per plant at both genotypic and phenotypic level.

Number of pods per plant exhibited positive and significant correlation with days to maturity, plant height and seed yield per plant. It shows weak positive correlation with days to 50% flowering, number of branches per plant and oil percentage at both genotypic and phenotypic level. Number of pods per plant was negatively correlated with 100 seed weight at both genotypic and phenotypic level. While it shows positive and significant correlation with number of pods per plant at genotypic level only.

100 seed weight was positively and significantly correlated with number of branches per plant at both genotypic and phenotypic level. It shows weak positive correlation with days to first flowering, days to 50% flowering, days to maturity and seed yield per plant. 100 seed weight was negatively correlated with plant height, number of pods per plant and oil content.

Oil content was positively and significantly correlated with days to maturity only at both genotypic and phenotypic level. It shows weak positive correlation with days to first flowering, days to 50% flowering, number of branches per plant and number of pods per plant. While it shows negative correlation with 100 seed weight and seed yield per plant at both genotypic and phenotypic level.

Table 6: Genotypic correlation coefficients between yield and yield contributing characters in Soybean

Characters	Days to first flowering	Days to 50% Flowering	Days to maturity	Plant Height (cm)	Number of branches per plant	Number of pods per plant	100 seed weight (g)	Oil content %	Seed yield per plant (g)
Days to first flowering	1.000	0.979**	0.584**	0.489**	0.252*	0.305*	0.060	0.060	0.335**
Days to 50% Flowering		1.000	0.559**	0.508**	0.350**	0.249	0.207	0.133	0.321*
Days to maturity			1.000	0.320*	0.115	0.354**	0.036	0.411**	-0.068
Plant Height (cm)				1.000	0.092	0.496**	-0.087	0.111	0.257*
Number of branches per plant					1.000	0.051	0.320*	0.022	0.264*
Number of pods per plant						1.000	-0.135	0.052	0.519**
100 seed weight (g)							1.000	-0.389**	0.059
Oil content %								1.000	-0.208
Seed yield per plant (g)									1.000

*, ** : significant at 5 and 1 per cent level, respectively

Table 7: Phenotypic correlation coefficients between yield and yield contributing characters in Soybean

Characters	Days to first flowering	Days to 50% Flowering	Days to maturity	Plant Height (cm)	Number of branches per plant	Number of pods per plant	100 seed weight (g)	Oil content %	Seed yield per plant (g)
Days to first flowering	1.000	0.958**	0.522**	0.394**	0.208	0.240*	0.036	0.052	0.299*
Days to 50% Flowering		1.000	0.508**	0.404**	0.312*	0.196	0.146	0.125	0.291*
Days to maturity			1.000	0.263*	0.107	0.323*	0.067	0.392**	-0.068
Plant Height (cm)				1.000	0.068	0.218	-0.038	0.093	0.229*
Number of branches per plant					1.000	0.045	0.273*	0.020	0.238*
Number of pods per plant						1.000	-0.123	0.045	0.496**
100 seed weight (g)							1.000	-0.354**	0.029
Oil content %								1.000	-0.189
Seed yield per plant (g)									1.000

*, **, *** : significant at 5 and 1 per cent level, respectively

4.4. Path analysis:

Path analysis between yield and yield contributing characters were carried out by considering genotypic correlation coefficient (Table 8).

4.4.1. Days to first flowering:

The result for path coefficient analysis revealed that days to first flowering had positive (12.523) direct effect on seed yield per plant. It had negative indirect effect on seed yield through days to 50% flowering, plant height, days to maturity, number of branches per plant, number of pods per plant and 100 seed weight. While it shows positive indirect effect on seed yield through oil content.

4.4.2. Days to 50% flowering:

The direct effect of days to 50 % flowering was negative (-11.367). It had shown positive indirect on seed yield through characters days to first flowering, plant height, days to maturity, number of branches per plant, number of pods per plant and oil content and negative indirect effect through 100 seed weight.

4.4.3. Days to maturity:

The character expressed positive direct effect (0.648) and negative indirect effect of days to first flowering, days to 50% flowering and oil content. Days to maturity also shows the positive indirect effect through characters plant height, number of branches per plant, number of pods per plant and 100 seed weight.

4.4.4. Plant height (cm):

Plant height had positive (2.303) direct effect on seed yield per plant and positive indirect effect through days to maturity. It had shown negative indirect effect on seed yield per plant through days to first flowering, days to 50%

flowering, number of branches per plant, number of pods per plant, 100 seed weight and oil content.

4.4.5. Number of branches per plant:

The character expressed positive direct effect (1.430) on seed yield per plant. It had positive indirect effect through days to maturity, number of pods per plant and 100 seed weight. It had shown negative indirect effect on seed yield per plant through days to first flowering, days to 50% flowering, plant height and oil content.

4.4.6. Number of pods per plant:

· Number of pods per plant exhibited positive direct effect (0.623) on seed yield per plant. It was recorded negative indirect effect through days to 50% flowering and plant height. Days to first flowering, days to maturity, number of branches per plant, 100 seed weight and oil content showed the positive indirect effect.

4.4.7. 100 seed weight:

100 seed weight positive direct effect (3.369) on seed yield per plant and positive indirect effect on seed yield via days to first flowering, plant height and oil content. It was recorded negative indirect effect through days to 50% flowering, days to maturity, number of branches per plant and number of pods per plant.

4.4.8. Oil content (%):

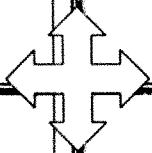
The character expressed negative direct effect (-1.287) on seed yield per plant and negative indirect effect through days to first flowering. It had positive indirect effect through days to 50% flowering, days to maturity, plant height, number of branches per plant, number of pods per plant and 100 seed weight.

Table 8: Direct and indirect effects (genotypic) of yield components on yield in Soybean

Characters	Days to first flowering	Days to 50% Flowering	Days to maturity	Plant Height (cm)	Number of branches per plant	Number of pods per plant	100 seed weight (g)	Oil content %	Seed yield per plant (g)
Days to first flowering	12.523	-11.124	-0.018	-0.005	-0.003	-0.247	-1.049	0.259	0.335**
Days to 50% Flowering	12.256	-11.367	0.043	0.102	0.071	0.071	-0.698	0.171	0.321*
Days to maturity	-0.344	-0.751	0.648	0.128	0.132	0.132	0.966	-0.029	-0.068
Plant Height (cm)	-0.029	-0.504	0.036	2.303	-0.413	-0.413	-1.243	-0.272	0.257*
Number of branches per plant	-0.030	-0.567	0.060	-0.665	1.430	1.430	1.132	-0.143	0.264*
Number of pods per plant	1.415	-1.342	0.146	-0.056	0.623	0.623	1.853	0.067	0.519**
100 seed weight (g)	3.897	-2.356	-0.186	0.849	-0.480	-0.480	3.369	0.501	0.059
Oil content %	-2.516	1.512	0.014	0.486	0.159	0.159	1.311	-1.287	-0.208

Residual effect = 0.762

DISCUSSION



DISCUSSION

Leguminous crops play an important role in Indian agriculture. Besides being rich in protein, they sustain the productivity of cropping system. Their ability to use atmospheric nitrogen through biological nitrogen fixation is economically sound and environmentally acceptable.

Soybean is one of the important oil seed crop in Indian agriculture. Being short duration and photo-insensitive, it can be grown round the year.

Evaluation of genotype is the pre-requisite to collect the basic information before initiating any breeding programme for the improvement of crop. Success of the crop improvement programme is largely dependent on the extent of genetic variability present in the population. Environment has a great influence on many quantitative characters, in which the variability partitioned into heritable and nonheritable components like genetic coefficient of variation, heritability, genetic advance etc. are most important to the plant breeder for selection of the breeding method in crop improvement programme.

Knowledge of the inter-relationship of quantitative traits of economic importance with seed yield and among themselves is important for the improvement in complex character like yield through selection. The correlation studies are helpful to some extent to the breeder, but they are not indicative of cause and effect relationship which restricts the practical utility of correlations in selection programme.

The technique of path coefficient analysis devised by Wright (1921) and utilized for the first time in plants by Dewey and Lu (1959) in crested wheat grass is efficient in disintegrating total correlation between two variables into direct and indirect effects. This technique could be used to understand the cause

of association between two variables and provides basis for selection of superior genotypes from the diverse breeding population.

The experimental material for present study consists of 27 soybean genotype with 3 checks. The genotypes were evaluated in randomized block design with three replications. The present investigation was undertaken to estimate genetic variability, heritability, genetic advance, correlation, path analysis and other observations discussed below.

5.1. Analysis of variance:

The analysis of variance for characters days to first flowering, days to 50% flowering, days to maturity, plant height, number of branches per plant, number of pods per plant, 100 seed weight, oil content and seed yield per plant showed significant genotypic differences indicating presence of variability among the genotypes selected for study (Table 3).

5.2. Mean performance:

The mean performance of different characters was studied and presented in table 4.

The genotypes MAUS-453 (35.33 days), MAUS-71 (36.33 days), MAUS-158 (35.33 days), MAUS-47 (36.33 days), AMS-243 (35.00 days), AMS-MB-5-18 (36.33 days), AMS-99-33 (36 days), MACS-1140 (35.66 days), MACS-1188 (36.66 days), MACS-1281 (35.00 days), MACS-1259 (36.33 days), KS-103 (36.66 days) and KS-106 (36.33 days) required less number of days to flowering than all three checks viz. JS-93-05 (37.33 days), JS-335 (37.33 days) and BRAGG (39.00 days) indicating earliness.

The fifteen genotypes MAUS-453 (38.33 days), MAUS-71 (39.33 days), MAUS-158 (38.33 days), MAUS-47 (39.66 days), AMS-243 (38.00 days), AMS-MB-5-18 (40.33 days), AMS-99-33 (39.00 days), MACS-1140 (39.66

days), MACS-1188 (39.66 days), MACS-1281 (39.00 days), MACS-1259 (40.66 days), KS-103(40.00 days), KS-106 (40.00 days) and JS-97-92 (40.66 days) required less number of days to 50% flowering than the all three checks JS-93-05 (42.33 days), JS-335 (41.00 days) and BRAGG (43 days).

The genotypes MAUS-453 (88.66 days), MAUS-521 (88.66 days), MAUS-449 (88.00 days), MAUS-47 (83.66 days), MAUS-61-2 (89.00 days), KS-112 (90.66 days), JS-97-92 (90.33 days) matures earlier than the all three checks JS-93-05 (92.66 days), JS-335 (96.00 days) and BRAGG (91.00 days) indicating the earliness.

The genotype MAUS-427 (56.33cm), MAUS-453 (90.32 cm), MAUS-521 (70.86 cm), MAUS-71 (61.66 cm), MAUS-81 (54.33 cm), MAUS-47 (61.40 cm), MAUS-61-2 (85.12 cm), AMS-243 (64.50 cm), MAS-MB-5-18 (70.40 cm), MAS-MB-5-19 (67.60 cm), AMS-99-33 (64.16 cm), MACS-1140 (54.33 cm), MACS-1188 (61.90 cm), MACS-1281 (58.70 cm), MACS-1259 (54.00 cm), KDS-378 (82.20 cm), KDS-384 (72.86 cm), KS-103 (68.60 cm), KS-106 (56.70 cm) and KS-112 (58.90 cm) showed higher plant height than the other genotypes and check BRAGG (53.80 cm) indicating the superiority over other genotypes.

Numbers of branches per plant were highest in genotype KDS-438 (5.73) followed by MACS-1188 (5.66), MAUS-348 (5.06), MACS-1259 (4.80), MAUS-158 (4.80) and significantly superior over the checks JS-93-05 (4.60), JS-335 (4.20) and BRAGG (4.46).

The highest number of pods noted in genotype KS-112 (99.60), while the lowest number of pods observed in genotype AMS-243 (33.46). The fourteen genotypes showed higher number of pods per plant than three checks JS-93-05 (41.40), JS-335 (46.30) and BRAGG (43.90).

Highest 100 seed weight values are observed in the genotypes MAUS-47 (14.88 g) followed by MAUS-427 (14.46 g), MAUS-423 (14.33 g), AMS-243 (14.15 g), MAUS-521 (14.02 g), MAUS-158 (13.73 g), AMS-MB-5-19 (13.65

g), AMS-MB-5-18 (13.56 g), AMS-99-33 (13.54 g), KDS-384 (13.15 g), and JS-97-92 (13.02 g) than all three checks JS-93-05 (12.15 g), JS-335 (12.96 g) and BRAGG (12.79 g).

The six genotypes MAUS-449 (20.90%), AMS-MB-5-19 (20.60%), MACS-1140 (21.00%), MACS-1281 (20.60%), MACS-1259 (20.70%), KS-106 (21.00%) showed more oil content than three checks JS-93-05 (19.90%), JS-335 (17.90%) and BRAGG (20.40%) and other genotypes.

Highest seed yield per plant was observed in genotype MAUS-158 (27.20 g) and the lowest value for seed yield per plant was found in genotype AMS-MB-5-18 (10.75%). Among the checks JS-335 (17.74 g) showed highest seed yield per plant followed by JS-93-05 (16.20 g) and BRAGG (13.90 g).

5.3. Genetic variability :

The extent of genetic variability present in any base population is most important for the success of breeding programme. Greater the variation in the material, better the chances for evaluating promising and desired types. The genetic variability is calculated from phenotypic observations which are the results of interactions of genotypes and environment. Since environment has a greater influence on many quantitative characters, the observed variability may be grouped under heritable and non-heritable components with the help of suitable parameters like genotypic coefficient of variation, heritability and genetic advance to decide the criteria of selection in a breeding programme.

5.3.1. Range of variability :

Wide range of variability was observed for majority of yield contributing characters. Range of variation on the basis of mean was more for traits viz. number of pods per plant, plant height, days to maturity, seed yield per plant, days to 50% flowering, days to first flowering, 100 seed weight, oil content and

number of branches per plant. Similar results were obtained by Chettri *et al.* (2005), Gupta and Punetha (2007) and Dhillon *et al.* (2005).

Estimates of phenotypic variance were found higher than the genotypic variance for all the characters. High genotypic variances were observed for the characters number of pods per plant followed by plant height, days to maturity and seed yield per plant. High phenotypic variances were observed for number of pods per plant followed by plant height, days to maturity and seed yield per plant. The present findings are in agreement with those of Sing *et al.* (1996), Sirohi *et al.* (2007), Gohil *et al.* (2006a) and Dhillon *et al.* (2005).

5.3.2. Genotypic and phenotypic coefficient of variation :

In the present investigation the phenotypic coefficient of variation were greater than the genotypic coefficient of variation but the differences between them were of lower magnitude, this indicates that there is less influence of environmental effect on expression of these characters and selection may be effective. The highest values for GCV and PCV for characters number of pods per plant, plant height, number of branches per plant and seed yield per plant indicating the possibilities of enhancement of these traits through selection. Similar observations were made by Gohil *et al.* (2006a), Sirohi *et al.* (2007) and Bhairav *et al.* (2006).

5.3.3 Heritability and genetic advance :

In crop improvement, only the genotypic component of variation is important since only that component is heritable and transmitted to next generation. Heritability indicates the effectiveness with which selection of genotypes would be based on phenotypic performance.

The broad sense heritability ranged from 48.10% (100 seed weight) to 98.87% (number of pods per plant). High heritability estimates were observed for oil content (88.65%), seed yield per plant (89.16%), number of branches per

plant (94.01%), days to 50% flowering (94.06%), days to first flowering (95.31%), days to maturity (96.48%) and plant height (98.25%).

The results obtained were in conformity with those obtained by Shukla *et al.* (1998), Dhillon *et al.* (2005), Rajanna *et al.* (2000), Malik *et al.* (2006) and Gupta and Punetha (2007).

High heritability for number of pods per plant (98.87%) , oil content (88.65%), seed yield per plant (89.16%), number of branches per plant (94.01%), days to 50% flowering (94.06%), days to first flowering (95.31%), days to maturity (96.48%) and plant height (98.25%), indicated the preponderance of additive gene effects. Therefore, further improvement through individual plant selection on the basis of these traits would be possible, whereas, lower heritability values indicated little scope for improvement in 100 seed weight (48.10 %).

Shift in gene frequency towards superior side under selection pressure is termed as genetic advance and is generally expressed as per cent of mean. Johnson *et al.* (1955) stated that in predicting the resultant effect of selection, the genetic advance should be considered along with the estimates of heritability. However, high genetic gain along with high heritability showed most effective condition for selection.

In the present study the high heritability coupled with high genetic advance was observed for number of pods per plant, plant height, number of branches per plant and seed yield per plant indicated that these characters are governed by additive gene action. Thus results indicated the substantial contribution of additive genetic variance in the expression of these characters and could be improved through individual plant selection. Similar results were also reported by Rajanna *et al.* (2000), Agrawal *et al.* (2001) for seed yield per plant and plant height and number of pods per plant and Dhillon *et al.* (2005) for seed yield per plant.

The results revealed high heritability coupled with low genetic advance for days to maturity, oil content, days to first flowering and days to 50% flowering. This indicated that selection would be ineffective for this character for further improvement. Similar result was obtained by Dhillon *et al.* (2005) Sahay *et al.* (2005) Karad *et al.* (2005) and Chettri *et al.* (2006).

5.4. Correlation :

Prior to any breeding programme for the improvement in crops for higher yield, it is imperative to obtain information regarding the inter-relationship of different characters with yield and among themselves since it facilitates the quicker assessment of high yielding genotypes. The real or the true association could be known through genotypic correlation, which eliminates the environmental influence. The result of present study, which revealed comparatively higher degree of genotypic correlation coefficient than their phenotypic counterparts in almost all the characters, indicated that there was a high degree of association between two characters at genotypic level; their phenotypic association was lessened due to the influence of environment. Similar findings were reported by Rajanna *et al.* (2000), Agrawal *et al.* (2001), Mukhekar *et al.* (2004), Vart *et al.* (2005) and Gaikwad *et al.* (2007).

In the present investigation, seed yield per plant was found to be positively and highly significantly correlated with days to first flowering, days to 50% flowering, days to maturity, plant height and number of pods per plant at both genotypic and phenotypic level indicating that these attributes were important for influencing the seed yield in soybean. Similar results were also obtained by Mukhedkar *et al.* (2004), Gohil *et al.* (2003), Vart *et al.* (2005), Taware *et al.* (1995), and Rajanna *et al.* (2000).

In the present investigation days to first flowering had positive and significant correlation with days to 50% flowering, days to maturity, plant height, number of branches per plant, number of pods per plant and seed yield

per plant, while it had weak positive correlation with 100 seed weight and oil percentage at the genotypic level.

Days to 50% flowering was significantly and positively correlated with days to first flowering, days to maturity, plant height and seed yield per plant at both genotypic and phenotypic level, while it shows positive and significant correlation with number of branches per plant at the genotypic level only. Days to 50% flowering has weak positive correlation 100 seed weight, number of pods per plant and oil content. Gohil *et al.* (2006b), Sahay *et al.* (2005) and Mukhekar *et al.* (2004) reported similar findings.

Days to maturity was significantly and positively correlated with days to flowering, days to 50% flowering, plant height, number of pods per plant and oil content. While it had positively correlated with number of branches per plant and 100 seed weight. Similar findings were also reported by Gohil *et al.* (2006b).

Plant height was significantly and positively correlated with days to flowering, days to 50% flowering, days to maturity, number of pods per plant and seed yield per plant. It shows weak positive correlation with number of branches per plant and oil content, while it had showed negative correlation with 100 seed weight at both genotypic and phenotypic level. Which indicated that direct selection for these traits would be helpful to increase the seed yield in soybean. Similar results were obtained by Gohil *et al.* (2006b), for days to maturity and days to 50 per cent flowering by Rajanna *et al.* (2000) and for days to maturity by Vart *et al.* (2005).

Number of branches per plant was significantly and positively correlated with 100 seed weight at both genotypic and phenotypic level, while it was positively and significantly correlated with days to 50% flowering at genotypic level. It was observed weak positive correlation with days to first flowering, days to maturity, plant height, number of pods per plant, oil content and seed

yield per plant at both genotypic and phenotypic level. Similar findings were also reported by Gohil *et al.* (2006b) and Sahay *et al.* (2005).

The trait number pods per plant exhibited positive and significant correlation with days to maturity, plant height and seed yield per plant. It shows weak positive correlation with days to 50% flowering, number of branches per plant and oil percentage at both genotypic and phenotypic level. Number of pods per plant was negatively correlated with 100 seed weight at both genotypic and phenotypic level. These are in accordance with the result of Vart *et al.* (2005) for plant height and days to 50 per cent flowering, Gohil *et al.* (2006b) for days to maturity, Gaikwad *et al.* (2007) and Mukhekar *et al.* (2005).

In the present investigation 100 seed weight was positively and significantly correlated with number of branches per plant at both genotypic and phenotypic level. It shows weak positive correlation with days to first flowering, days to 50% flowering, days to maturity and seed yield per plant. 100 seed weight was negatively correlated with plant height, number of pods per plant and oil content. Similar results were obtained Mukhekar *et al.* (2005), Gohil *et al.* (2006b) and Chettri *et al.* (2003).

Oil content was positively and significantly correlated with days to maturity only at both genotypic and phenotypic level. It shows weak positive correlation with days to first flowering, days to 50% flowering, number of branches per plant and number of pods per plant. While it shows negative correlation with 100 seed weight and seed yield per plant at both genotypic and phenotypic level. Similar results were obtained Mukhekar *et al.* (2005) and Gohil *et al.* (2006b).

Thus result revealed that plant height, number of pods per plant, days to 50 first flowering and days to maturity had positive and highly significant association with seed yield. So more emphasis should be given to these characters during selection for higher yield in soybean crop.

5.5. Path analysis discussion

Yield is a complex character and is the multiplicate end product of several component traits. Some of them may be grouped as main components which directly contribute towards yield, whereas, others may not contribute directly to the yield but indirectly may influence the yield by changing the behavior and growth of different components, therefore it would be better to know how the yield is directly and indirectly influenced by other characters.

The simple correlation, being calculated on an average basis, may not give a clear picture of the cause effect system operating on the material selected for study. However, when variables increase then the situation becomes complex; then computation of path analysis that facilitates the partitioning of genotypic correlation into direct and indirect effect of various characters becomes necessary.

In order to achieve a clear picture of inter relationship of various component characters with yield, direct and indirect effects were calculated using path coefficient analysis at genotypic level.

Days to first flowering had positive direct effect on seed yield per plant. It had negative indirect effect on seed yield through days to 50% flowering, plant height, days to maturity, number of branches per plant, number of pods per plant and 100 seed weight. While it shows positive indirect effect on seed yield through oil content. Similar results were reported by Gohil *et al.* (2006b)

The direct effect of days to 50 % flowering was negative. It had shown positive indirect on seed yield through characters days to first flowering, plant height, days to maturity, number of branches per plant, number of pods per plant and oil content and negative indirect effect through 100 seed weight. Similar results were reported by Gohil *et al.* (2006b)

The character days to maturity expressed positive direct effect and negative indirect effect through days to first flowering, days to 50% flowering

and oil content on seed yield. Days to maturity also shows the positive indirect effect through characters plant height, number of branches per plant, number of pods per plant and 100 seed weight. This result is in confirmation with the results of Gohil *et al.* (2006b) and Chettri *et al.* (2003).

Plant height had high positive direct effect and highly significant positive correlation with seed yield per plant and positive indirect effect through days to maturity. It had shown negative indirect effect on seed yield per plant through days to first flowering, days to 50% flowering, number of branches per plant, number of pods per plant, 100 seed weight and oil content. This result is in confirmation with the results of Gohil *et al.* (2006b) and Mukhekar *et al.* (2004).

The character number of branches per plant depicted positive direct effect on seed yield per plant. It had positive indirect effect through days to maturity, number of pods per plant and 100 seed weight. It had shown negative indirect effect on seed yield per plant through days to first flowering, days to 50% flowering, plant height and oil content. Gohil *et al.* (2006b) also found similar results.

Number of pods per plant exhibited positive direct effect on seed yield per plant. It is in agreement with results of Rajanna *et al.* (2000), Iqbal *et al.* (2003) and Gohil *et al.* (2006b). It was recorded negative indirect effect through days to 50% flowering and plant height. Indirect effect of number of pods per plant through days to first flowering, days to maturity, number of branches per plant, 100 seed weight and oil content showed positive indirect effect. Similar results were also found by Mukhekar *et al.* (2004) and Vart *et al.* (2005).

100 seed weight exerted positive direct effect on seed yield and positive indirect effect through days to first flowering, plant height and oil content and negative indirect effect through days to 50 % flowering, days to maturity, number of branches per plant and number of pods per plant. Gohil *et al.* (2006b) and Mukhekar *et al.* (2004) reported similar findings.

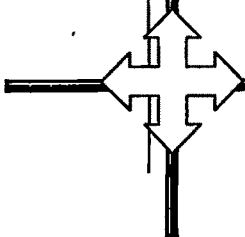
Oil content was reported negative direct effect on seed yield per plant. Its indirect effect on yield was observed negative through days to first flowering and its indirect effect on seed yield was positive through days to 50 % flowering, days to maturity, plant height, number of branches per plant, number of pods per plant and 100 seed weight. Similar results were reported by Saharan *et al.* (2006) and Gohil *et al.* (2006b).

The present investigation clearly revealed that the characters days to first flowering, 100 seed weight, plant height, number of branches per plant, days to maturity and number of pods per plant had strong association with seed yield per plant and also showed positive direct effect and indirect effect through other component traits. This indicated that direct selection for these characters will enhance the breeding efficiency for seed yield in soybean.

The characters days to 50 % flowering had negative direct effect but significant genotypic correlation with seed yield indicated that this character showed desirable association with yield through positive indirect effect of characters viz, days to first flowering, days to maturity, plant height, number of branches per plant, number of pods per plant and oil content.

The traits number of pods per plant and 100 seed weight showed positive direct effect and non significant correlation with seed yield revealed that the association of these traits with seed yield parameter will be improved through selection of characters showing positive indirect effect on seed yield of soybean.

SUMMARY AND CONCLUSION



Chapter-VI

SUMMARY AND CONCLUSION

The present investigation on genetic variability, correlation coefficient and path analysis among nine characters was carried out in a set of thirty genotypes of soybean [*Glycine max* (L.) Merrill]. The experiment was laid out in a randomized block design with three replications during *kharif* season 2011, at Experimental Farm of Department of Agricultural Botany, College of Agriculture, Latur.

The findings of present investigation are briefly summarized as under:

- [1] The analysis of variance for all the nine characters of thirty genotypes revealed significant differences among the genotypes studied, indicating sufficient amount of variability present in the material.
- [2] The genotypic as well as phenotypic variances were high for number of pods per plant, plant height and days to maturity, whereas moderate for seed yield per plant and days to 50 per cent flowering, days to first flowering and low for 100-seed weight, number of branches per plant and oil content.
- [3] The genotypic coefficient of variation was observed high for number of pods per plant followed by plant height, number of branches per plant, seed yield per plant and 100 seed weight, thereby indicating considerable amount of variability in the material for these traits.
- [4] High heritability estimates were obtained for number of pods per plant, plant height, days to maturity, days to first flowering, days to 50% flowering, number of branches per plant, seed yield per plant and oil content indicating that these characters were less influenced by environment and direct selection for these characters would be effective for further improvement in yield level.

[5] Genetic advance expressed as per cent of mean was observed high for number of pods per plant followed by plant height, number of branches per plant and seed yield per plant. High heritability coupled with high genetic advance as per cent of mean for these traits were indicative that preponderance of additive gene action in the expression of these traits and more emphasis should be given to these characters while selection for further improvement in yield.

[6] Low heritability with low genetic advance was observed for oil content indicating poor response to selection.

[7] In general, genotypic correlations were higher than the phenotypic correlations.

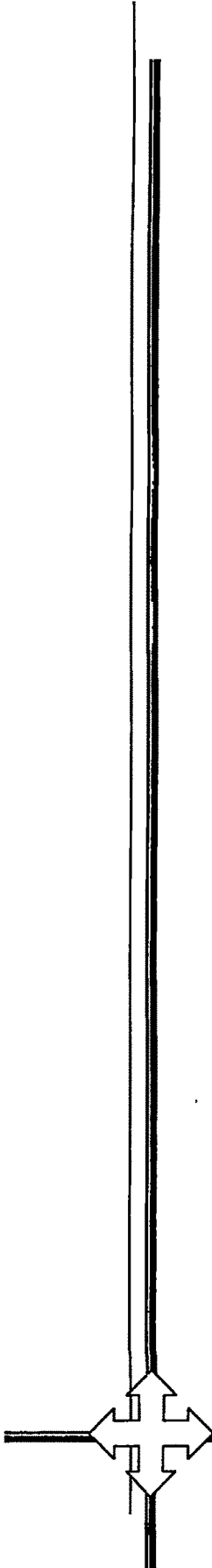
[8] Seed yield per plant showed significant and positive correlations with plant height, number of pods per plant, days to 50 per cent flowering, days to first flowering days to maturity and number of branches per plant.

[9] Path coefficient analysis revealed the highest positive direct effect of days to first flowering on seed yield followed by 100 seed weight, plant height, number of branches per plant, days to maturity and number of pods per plant. Days to 50% flowering and oil content had negative direct effects.

[10] From the results of present investigation it was found that characters seed yield per plant, plant height, number of pods per plant and number of branches per plant had the high heritability coupled with high genetic advance as per cent of mean which indicated the predominance of additive gene effects, Thus mass selection and progeny selection is advocated for further improvement in seed yield.

Conclusion :

The investigation carried out in present study revealed that the characters plant height, number of pods per plant, number of branches per plant and seed yield per plant were the most important characters for effective selection of superior genotypes for improvement in seed yield of soybean as they expressed high heritability coupled with high expected genetic advance and significant positive correlation. Thus the utilization of genotypes MAUS-453, MAUS-449, MAUS-158, MAUS-47, KDS-638 and KS-112 identified as superior ones for the above traits in breeding programme will increase the practical utility of the investigation in improving the soybean yield level.



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ANNEXURE

ABSTRACT

**“GENETIC VARIABILITY, CORRELATION AND PATH ANALYSIS FOR SEED
YIELD AND YIELD CONTRIBUTING CHARACTERS IN SOYBEAN**

(*Glycine max* (L.) Merrill)”

By

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in

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The present investigation on genetic variability, correlation coefficient and path analysis among nine characters was carried out in a set of thirty genotypes of soybean [*Glycine max* (L.) Merrill]. The experiment was laid out in a randomized block design with three replications during *kharif* season 2011, at Experimental Farm of Department of Agricultural Botany, College of Agriculture, Latur.

The analysis of variance for all the characters of thirty genotypes revealed significant differences among the genotypes studied, indicating sufficient amount of variability present in the material. The genotypic as well as phenotypic variances were high for pods per plant, plant height, days to maturity and seed yield per plant. The genotypic coefficient of variation was observed high for number of pods per plant followed by plant height, number of branches per plant and seed yield per plant and, thereby indicating considerable amount of variability in the material for these traits. High estimates of heritability were observed for number of pods per plant, plant height, days to maturity, days to first flowering, days to 50 % flowering and number of branches per plant indicating that these characters were less influenced by environment and direct selection for these characters would be effective for further improvement in yield level. The expected genetic advance expressed as per cent of mean was observed high for number of pods per plant followed by plant height, number of branches per plant and seed yield per plant. High heritability coupled with high genetic advance as per cent of mean for these traits were indicating that more emphasis should be given to these characters while making selection for further improvement in yield.

In general, genotypic correlations were higher than the phenotypic correlations. Seed yield per plant showed significant and positive correlations with plant height, number of pods per plant, days to 50 per cent flowering and days to maturity.

Path coefficient analysis revealed the highest positive direct effect of days to first flowering on seed yield followed by 100 seed weight, plant height and number of branches per plant. Suggesting their importance while making selection for improvement in grain yield.

VITA

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